Letters to the Editor

The Occupation of Newly Irrigated Lands by Earthworms

When the grasslands of the Riverine plain are irrigated and sown with exotic herbage plants, leaf litter and dung accumulate on top of the ground. The partly decomposed material forms a mat distinct from the underlying mineral earth. After four years the mat may be 1 cm thick, and after 10 to 15 years it is often 2 to 4 cm thick. As much as 1200 Kg per hA of nitrogen has been found in the thicker mats.

The endemic fauna that incorporates plant litter in the soil is not effective on the irrigated pastures. For example, litter feeding Termitidae are common on the natural grasslands, but are not found on irrigated pastures. Although earthworms occur along the banks of watercourses and in wet places,* they have not been found on the dry plains north of Deniliquin. Our observations suggest that, when the irrigated pastures are occupied by earthworms, mixing of voided earth with the litter leads to the disappearance of the discrete mat.

Michaelsen (1907) has shown that peregrine earthworms, particularly lumbricids of the *Allolobophora caliginosa* complex (Gates, 1958), are spread in areas developed for agriculture. His collections in south-western Australia showed that *A. caliginosa* had been widely spread through the agricultural zone and had become numerous near towns within 70 years of the first settlement by Europeans. The worms are transported with potted plants, and the cocoons are thought to be carried in soil on the hooves of livestock (Lee, 1958).

Our observations on the Riverine Plain were first made at the C.S.I.R.O. field station 20 Km north of Deniliquin in 1950. Irrigated pastures had been established for four years, but no earthworms were found. Further observations were made in 1954 when the pastures at the field station were eight years old: Groups of *A. caliginosa* and of *Eisenia rosea* (Savigny) were found near houses at the field station, where gardens had been planted. *A. caliginosa* were also found along a drainage ditch, but none were found on the irrigated pastures. A reconnaissance of the district around Deniliquin showed that numerous worms of the *A. caliginosa* complex were present on some eight-year-old pastures on loamy soils. On other paddocks of similar age, and on similar soils, no worms were found. The discontinuities suggested that transport by man or livestock might be controlling the distribution.

In 1955 mature *A. caliginosa* were collected from home gardens in Deniliquin, where they were common together with a peregrine megascolecid, *Microscolex dubius* (Fletcher). At the field station the three irrigated paddocks described in Table 1 were inoculated with lots of 175 worms placed 10 m apart, five sites being inoculated in each paddock. Observations were made six months after inoculation. On the clay (Plain 5) one or two casts were seen but no worms were found. There were numerous casts on the loams, and on the perennial pasture (Levee 5) the mat had been mixed and covered with casts over an area 1 m in diameter at each site. Observations were next made in 1963, when the only worms that could be found on Plain 5 were a few groups of *M. dubius* living in a thick mat of plant litter and dung. On Levee 5 dense populations of *A. caliginosa* and *M. dubius* were found. The number and weight of worms is shown in Table 2. On Levee 1 a dense population of *A. caliginosa* was present on the side

TABLE 1

Description of the paddocks inoculated with A. caliginosa in 1955

Paddock	Date of Sowing	Soil	Pasture*
Plain 5	1947	Riverina clay	Perennial
Levee 1	1950	Conargo sandy loam	Annual
Levee 5	1947	Conargo sandy loam	Perennial

* The perennial pastures were irrigated throughout the summer; but the annual pasture was irrigated only in autumn and spring.

TABLE 2

Earthworm populations found on irrigated pastures

Worms were expelled by applying dilute formalin (Raw, 1959) to quadrats of 1 m diameter. After 30 mins. a 33 cm diameter core was excavated from the centre of each quadrat to a depth of 30 cm, and worms that had not been expelled by the formalin were sorted out by hand. The sum of the two catches, expressed as number and weight of worms per sq.m., is shown in the table. The worms were collected into 5 per cent formalin, identified, and weighed. The weight in this solution is about 25 per cent less than the fresh weight

Paddock	No. per sq. m.		Weight (g per sq. m.)		Percentage by number	
	Mean	s.e.	Mean	s.e.	*A. calig.*	*M. dubius*
Plain 5	5	—	2	—	0	100
Levee 1						
Not inoculated	2	—	2	—	*	*
Inoculated area	303	87	162	33	100	0
Levee 5	279	28	167	18	88	12

* Insufficient worms were caught to determine the proportions, but both species were present.

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* The following species were collected along watercourses near Deniliquin: *Plutellus attenuatus* (W. B. Spencer), *Megascolex exiguus* (Fletcher), *Megascolex macleayi* (Fletcher), *Eiseniella tetraedra* (Savigny) forma *typica*.

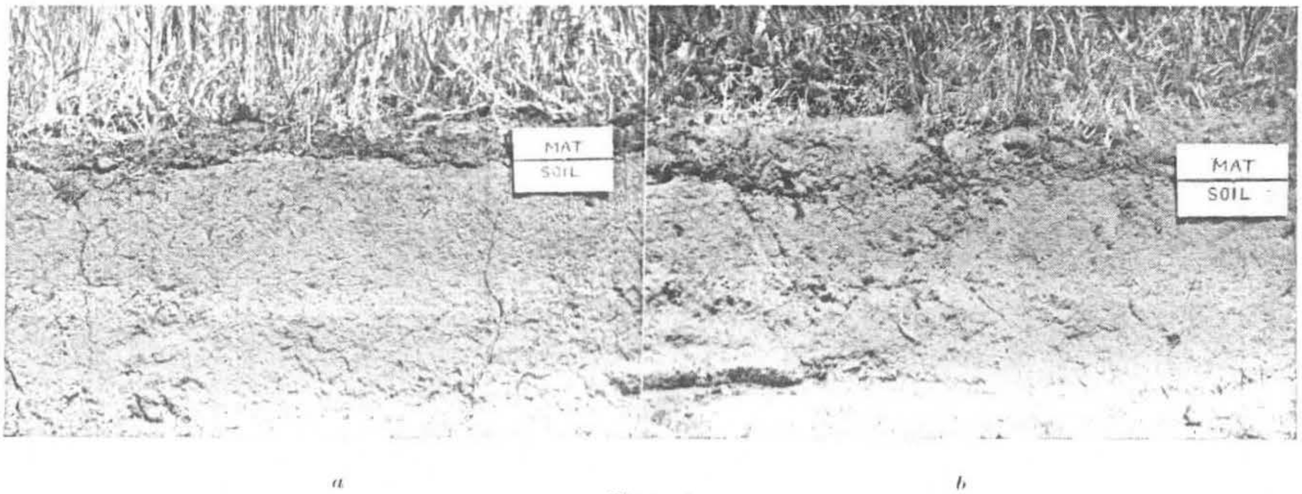

Figure 1
The appearance of the soil (*a*) before and (*b*) after the establishment of a dense population of earthworms.

of the paddock that had been inoculated. On the other side, 200 m away, few worms were found (see Table 2). These occurred in patches. Where dense populations were present, earth had been mixed with the mat and the area between the bases of plants was covered with casts (Figure 1).

At the C.S.I.R.O. station observations were also made on an irrigated area isolated from the other irrigated areas on the property. This area known as ' Rose's ' was 2 Km from the nearest paddocks known to contain large numbers of worms, and was at the end of a long supply channel that flowed for 7 Km from the nearest irrigated paddock upstream. The pastures on Rose's were ten years old, and were on loams similar to those that supported dense populations on Levees 1 and 5. No worms were found in three paddocks each about 6 hA in area in Rose's, and an undisturbed mat of plant debris and dung was present.

Although insufficient observations have been made to test hypotheses describing the distribution of earthworms in the region, it seems likely that the region is being occupied by exotic earthworms for the first time, and that a lag of ten or more years may sometimes occur before the establishment of an earthworm fauna on irrigated land. It is not known whether the populations on the inoculated paddocks resulted from the inoculation, or from chance introductions by sheep or with irrigation water.

Riverina clay does not appear to offer an environment suitable for *A. caliginosa*, even when irrigated throughout the year and covered with a large amount of litter and dung. It would be interesting to know whether this soil is made suitable by amelioration with gypsum which improves its physical condition (Barley and Hutton, 1956). Alternatively, other species of earthworm may be found that could live and multiply in the clay.

There is some evidence from field trials in New Zealand to show that the introduction of *A. caliginosa* can mix plant litter with the soil and lead to an increase in the yield of sown pastures (Hamblyn and Dingwall, 1954 ; Richards, 1955 ; Stockdill, 1959). In the New Zealand experiments the worms were deliberately introduced into areas that were isolated, or where the soils were naturally acid and had recently been limed. In our observations the effect of the earthworms on the loamy soils was very striking. It will be of much interest to discover whether the disappearance of the mat has any effect on the productivity of the pasture.

Abbie (1954) suggested that the introduction of a new earthworm fauna may have changed, or may be likely to change, the fertility or development of Australian soils. Abbie's suggestion appears to be particularly profitable when applied to newly irrigated lands.

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